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(72) Inventor RICHARD EDWARD EPWORTH

(54) AVALANCHE PHOTODETECTOR DEMODULATION

(71) We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company of 190 Strand, London W.C.2, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a demodulation arrangement for an optical communication system.

In optical communication systems, e.g. utilising optical fibres as the transmission medium, it is possible to impose amplitude modulation on digitally modulated optical signals to provide an additional low frequency channel which may be used, for exmaple, as a supervisory channel or engineer order wire, operating at audio frequencies.

According to the present invention there is provided a demodulation arrangement for an optical communication system in which digitally modulated optical signals have imposed thereon amplitude modulation at a frequency substantially below the digital frequency comprising an avalanche photodetector diode connected in series with a d.c. source having an impedance high enough to produce a negative feedback effect on the gain of the photodetector diode, a first signal output being derived from the connection between the source and the diode, a low noise amplifier the input of which is connected to the other side of the diode, and means for a.c. decoupling the source from the diode over the range of digital frequencies, the output of the low noise amplifier providing a second signal output.

An avalanche photodetector diode (APD) is defined as one in which the breakdown phenomena due to reverse biasing of the diode is controlled to provide a relatively linear and noiseless gain function when the device is biased to have a gain factor not exceeding a few hundred, typically 100-500 maximum. The APD is normally biased at such a current that optimum gain occurs at the nominal receiver optical power level, and the device is chosen so that at this level it is working well below its maximum gain. In an APD the current gain in amps per watt is m times greater than in the simple photodetector diode (where m is the multiplication factor). The gain versus applied bias voltage is a steep curve, Fig. 1(a), but for a many APD's a plot of $1/m$ versus applied bias voltage approximates to a straight line, Fig. 1(b).

Conventionally an APD is biased by a low impedance source (low at least at signal frequencies) to ensure that the gain m is held constant despite variations in the light induced current. If the APD is biased from a constant current source I_{con} (low pass filtered to look like a voltage source at signal frequencies), Fig. 2, the diode current is therefore forced to be constant and thus the gain must vary to satisfy the conditions. For example, if the optical signal swings over a range of 10 to 100%, then the gain must swing over a range of 10 to 1. For constant current, the reciprocal of the gain $1/m$ will be proportional to received optical power. Now from Fig. 1(b) it will be seen that the bias voltage will swing up and down in antiphase to the modulation. Thus the bias voltage can provide a demodulated output V_{out} instead of the usual current output.

Embodiments of the invention will now be described with reference to Figs. 3 and 4 of the accompanying drawings which illustrate two stages in the development of the demodulation arrangement.

In the simple arrangement shown in Fig. 3 an APD is connected in series with a constant current source I_{con}. The low frequency (audio) signal which is conveyed as an amplitude modulation of the transmitted light is demod-lated and coupled out as a voltage V_{out} from the connection between APD and I_{con}. The other side of the APD is connected to the input of a conventional low noise differential amplifier to provide the demodulated digital output D_{out}. It is necesary to include in the connection from the source side of the APD a capacitor C or a low pass filter to decouple the source

I_{out} from the amplifier at the normal digital signal frequencies. It is advisable that the low frequency (audio) signal is amplitude modulated with a low modulation depth to prevent disruption of the main optical transmission receiver.

To eliminate the "eye" closure due to the use of amplitude modulation it may be necessary to insert an automatic gain control AGC with suitable time-constants into the digital output, as shown in Fig. 4. It is possible to use an a.g.c. alone to extract the a.m. component.

WHAT WE CLAIM IS:—

1. A demodulation arrangement for an optical communication system in which digitally modulated optical signals have imposed thereon amplitude modulation at a frequency subtsantially below the digital frequency comprising an avalanche photodetector diode connected in series with a d.c. source having an impedance high enough to produce a negative feedback effect on the gain of the photodetector diode, a first signal output being derived from the connection between the source and the diode, a low noise amplifier the input of which is connected to the other side of the diode, means for a.c. decoupling the source from the diode over the range of digital frequencies, the output of the low noise amplifier providing a second signal output.

2. An arrangement according to claim 1 including an automatic gain control circuit to which the output of the low noise amplifier is applied.

3. A demodulation arrangement substantially as described with reference to Fig. 3 or Fig. 4 of the accompanying drawings.

S. R. CAPSEY,
Chartered Patent Agent,
For the Applicants.

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Fig. 1.

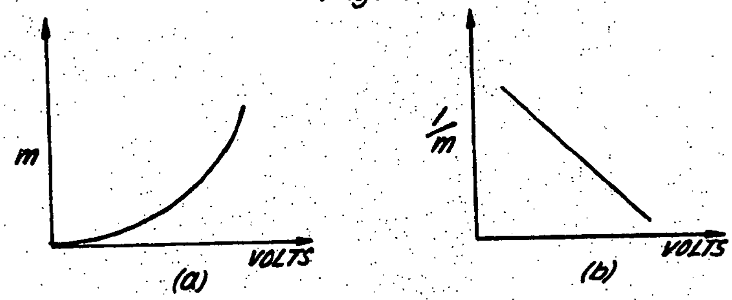

Fig. 2.

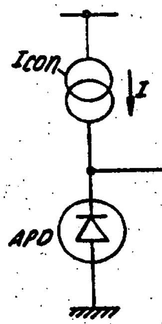

Fig. 3.

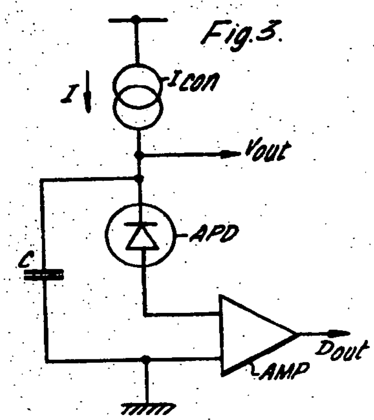

Fig. 4.